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EVALUATION OF LUBRICATING COMPOSITES FOR THE M16A1 RIFLE

GEORGE P. MURPHY, JR. BERNARD J. BORNONG

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RESEARCH DIRECTORATE

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the five composite-lubricated rifles had an average of six malfunctions to with one in the original test. Three of the rifles were terminated before 10,000 rounds because of the fracture of the inserts. In one of these rifles the bolt se sealing ring insert broke; this action caused the sealing ring to break. In the other two composite-lubricated rifles removed from test, the inserts in the cam path area fractured and fell out because, when the insert hole was machined, it broke through the cam path wall. The impact of the cam pin against the exposed portion of the insert eventually caused cracking. Nevertheless, there tests have demonstrated the feasibility of the use of the self-lubricating inserts. However, care must be exercised to insure that the inserts fit properly and are backed up with sufficient high-strength material.

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OBJECTIVE

The objective of this program was to evaluate self-lubricating composites for application to the Ml6Al rifle to reduce maintenance and to improve reliability and durability.

BACKGROUND

A previous report by Martin and Murphy¹ indicated that a self-lubricating composite applied to an M16Al rifle reduced its malfunction rate compared with that obtained during firing tests on unlubricated rifles and rifles with MIL-L-46000 Lubricant. The composite was a metal matrix of molybdenum, niobium, and copper with molybdenum disulphide as the solid lubricant. This material was applied as inserts in the bolt carrier tracks, bolt carrier key, and bolt sealing ring area of the gas cylinder.

Since the previous results were based on the firing of only one rifle containing the self-lubricating composite inserts, firing tests on several additional rifles lubricated with the composite insets were considered necessary to verify the original results.

APPROACH

The bolt carrier of five M16Al rifles were modified by placement by self-lubricating composites in the bolt carrier tracks, in the bolt carrier key, and in the gas cylinder wall in contact with the bolt sealing rings. These rifles, along with a rifle lubricated with MIL-L-46000 as a control, were fired for a maximum of 10,000 rounds, and the malfunctions and firing rates were determined.

PROCEDURE

The bolt carrier track, bolt carrier key, and bolt carrier in the gas cylinder wall in which the bolt sealing rings made contact, were drilled to hold the self-lubricating composites. These machined areas are shown in Figures 1, 2, 3. An insert is already in place in the bolt carrier and in the carrier key. Note, in Figure 1, that the insert hole at the far left of the upper track in the cam path area broke through the wall of the cam path. The consequences of these holes in the cam tracks on the test results will be considered later in this report, in the Results and Discussion section. At the time that these holes were discovered, funding and time limitations would have lead to decision to terminate the test rather than re-do a new set of bolt carriers. A decision was made to proceed with the test after the composite inserts were filed flush with the cam track surfaces.

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^{1.} P. Martin, Jr., and G. Murphy, Jr., General Thomas J. Rodman Technical Report R-TR-75-005, "Application of Lubricating Composites to the M16Al Rifle." December 1974.



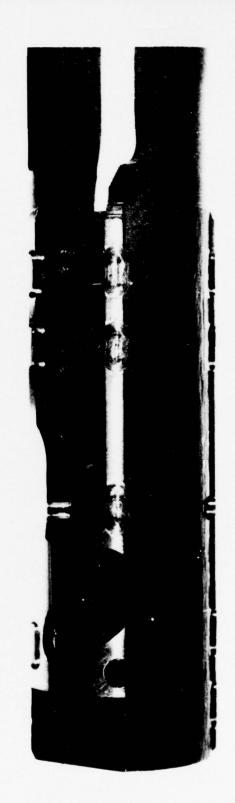


Figure 1. Left Side View of Bolt Carrier Showing Holes for Composite Inserts.

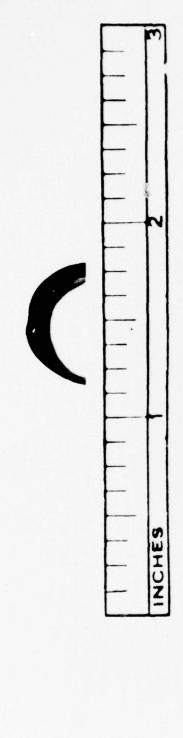




Figure 2. Right Side View of Bolt Carrier Showing Holes of Composite Inserts.



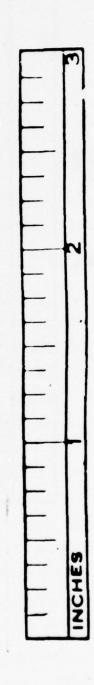


Figure 3. Side View of Bolt Carrier Key Showing Hole and Composite Insert in Place.

The shape of most of the composite inserts was changed from cylindrical in the first test to an oblong shape, as shown in Figure 1. The purpose of this change in shape was to provide increased surface area to decrease the bearing load on the composite and to make more of the composite available for lubrication.

The types of composite inserts used are shown in Figure 4. These inserts were glued in place with epoxy resin, as shown in Figures 5 and 6. The composite inserts were then ground down until they protruded .005 inch above the surfaces to which they were applied. The appearance of the bolt carriers after this grinding process is shwon in Figures 7 and 8.

After the inserts were ground down, the five composite rifles and the control rifle were cleaned. The control rifle was lubricated normally with MIL-L-46000A Lubricating Oil, Semi-Fluid (Automatic Weapons). The six rifles were tested by personnel of the Weapons Test Division (SARRI-RIE-T) following this firing test plan:

A. Firing Test Schedule.

Fire according to the following schedule with five 20-round magazines loaded in sequence without any delays:

- a. Fire 100 rounds, automatic.
- b. Cool rifle to ambient temperature (maximum, 1 hour).
- c. Fire 100 rounds, semi-automatic (1 second between rounds).
- d. Cool rifle to ambient temperature (maximum, 1 hour).
- e. Repeat firing sequence a through d until 10,000 rounds have been fired or failure of the weapon to fire occurs.

B. Instrumentation.

Determine rate of fire (rounds per minute) during step a given above, preferably on the first magazine.

C. Special Instructions.

- a. Using ball ammunition, fire the first 5,500 rounds from a firing jack. Using a mixture of 4 ball to 1 tracer, fire the next 500 rounds from the firing jack. Using amixture of 4 ball to 1 tracer, fire the remaining 4000 rounds from the shoulder.
- b. Replace any parts that break during firing, and continued the test.
 - c. Assess all malfunction as to type and probable cause.



Figure ${\boldsymbol \mu}_\bullet$ Types of Self-Lubricating Composites Used.



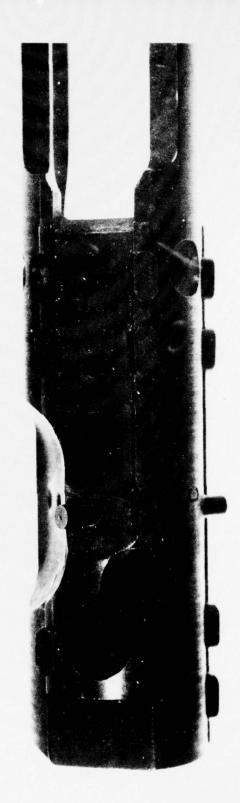


Figure 5. Left Side of Bolt Carrier Showing Inserts in Place.

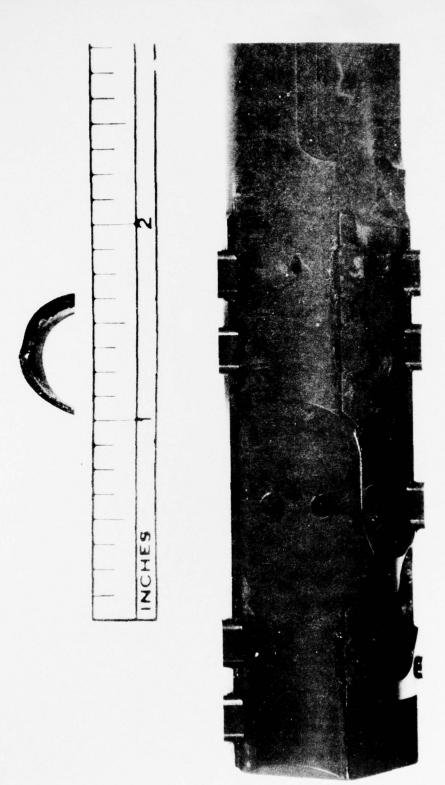


Figure 6. Right Side of Bolt Carrier Showing Inserts in Place.

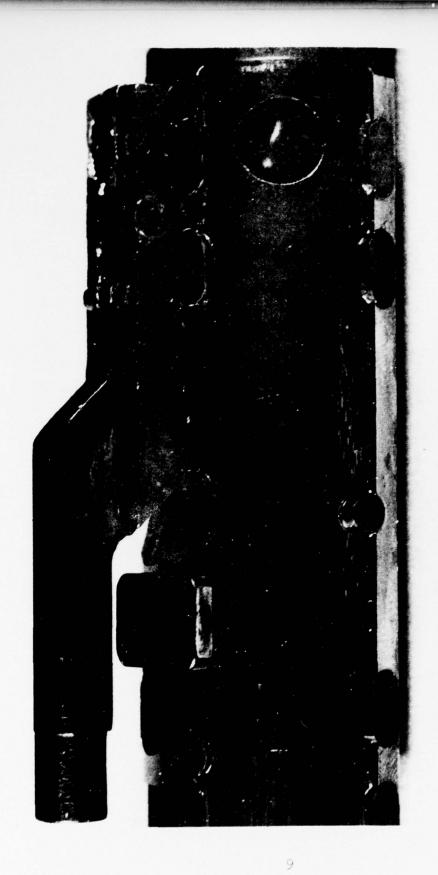


Figure 7. Left Side View of Bolt Carrier With Inserts Ready for Test.

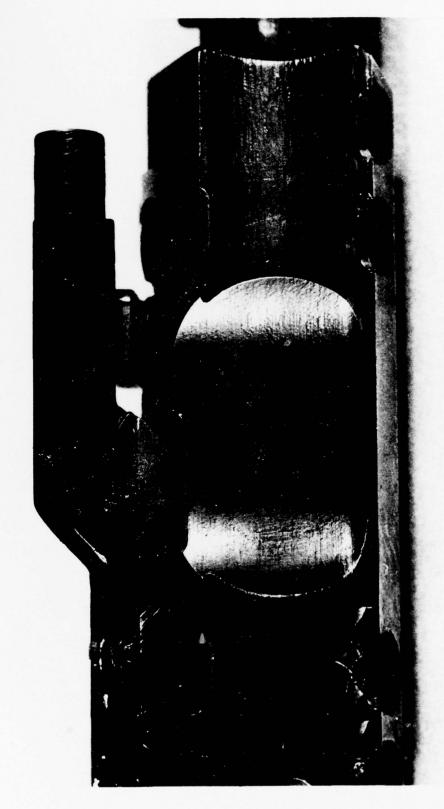


Figure 8. Right Side View of Bolt Carrier With Inserts Ready for Test.

- d. Terminate the test when a malfunction rate of 25 per 100 rounds occurs.
 - e. Do not clean or lubricate the weapons during the test.

RESULTS AND DISCUSSION

Two table designations are referred to in the body of this report, i.e., those that have a prefix A such as Table A-1 and those that do not have a prefix such as Table 1. Those tables with the prefex A that are found in Appendix A give the raw individual malfunction and firing rate data. Those tables without the prefix A provide an analysis of the data given in the appendix.

The firing rate data are given in Table A-1 in appendix A. The raw data were averaged in 1000-round intervals, and these averages are given in Table 1. The overall average firing rate of four composite rifles Nos. 1, 2, 3, and 5 is 809 rounds per minute, which is in agreement with the 800-round-per-minute figure for the original composite rifle test. Rifle No. 4 was excluded from the average because of the short time that it was in the test. Like the original composite rifle test, the firing rate for each of the 4 composite rifles was relatively constant.

Note that Rifle No. 6, lubricated with ML-L-46000A, had an average firing rate of 912 rounds per minute, which is much higher than the 761-round-per-minute value for the ML-L-46000A-lubricated rifles obtained in the previous firing test. The high firing-rate of this rifle is unexplainable since it was prepared for firing in the same manner as the rifles in the previous test. Futhermore, the average firing rates of the composite-lubricated rifles used in the two tests were essentially the same.

The malfunction type and number given in Tables A-2 to A-7 are summarized in Table 2; of the

Table 2
SUMMARY OF MALFUNCTIONS BY TYPE

		COMPOSI	TE-LUBR	ICATED		MIL-L-46000A LUBRICATED
Malfunction	Rifle	Rifle	Rifle	Rifle	Rifle	Rifle
Type *	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
FF-FBL	1	3	10	0	6	0
FFr-L.I.	5	27	3	1	13	5
FFr-U	0	0	0	0	0	2
FX	0	6	0	1	0	0
FJ	0	0	0	9	0	0
FF-BOB	0	1	0	0	0	0
FF-SB	0	0	0	1	O	0
TOTAL	6	37	13	11	19	7

* See page 18 for identification of Malfunction types.

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TABLE 1

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AVERAGE FIRING RATE FOR 1000-ROUND INTERVALS

ROTATION		FIR	FIRING RATE (ROUNDS PER MINUTE)	SS PER MINUTE)		MTTT16000A
FIRED	Rifle No. 1	Rifle No. 2	Rifle No. 3	Rifle No. 4	Rifle No. 5	Lubricated Rifle No. 6
		t		i		200
1000	760	760	770	710	190	875
2000	775	805	795	750 (2)	840	920
3000	810	845	840		875	970
7000	820	835	840		850	920
2000	820	815	840		870	935
0009	810	820	840		850	910
7000	770 (1)	780	785		810	880
8000		092	785		805	(4) 068
0006		790	805		820 (3)	
10000		775	810			
OVERALL AVERAGE	795	798	811	730	834	912
E	COO 7	9	C	Service FOOD to Entra menot took	+ 0005 2002	

Test terminated at 6903 rounds. Test terminated at 1836 rounds. 5 ;

Test terminated at 9095 rounds. ÷ %

Test terminated at 7904 rounds.

malfunction types, only the first three namely FF-FBL, FFr-II, and FFr-U were considered to be caused by the lubrication of the bolt carrier group.

The malfunctions due to the lubrication of the bolt carrier group will be discussed separately for each rifle. With respect to the composite-lubricated Rifle No. 1, 6 malfunctions occurred. Malfunction FF-FBL was due to the bolt carrier group. With respect to the 5 FFr-LI malfunctions, 3 were due to bad ammunition and were not considered to be bolt-carrier related. The other 2 occurred shorthly before the test of Rifle No. 1 was terminated at 6903 rounds. The rifle was removed from the test at this point because the insert adjacent to the cam path had fractured. The broken insert caused the last two FFr-LI malfunctions. Because these two malfunctions might not have occurred if the insert had not broken, they were not considered lubrication malfunctions. The breakage occurred because the insert was exposed to the impact of the cam throught the hole made in the cam path wall during machining. Therefore, Rifle No. 1 had only one malfunction due to the bolt carrier group.

Rifle No. 2 completed the full 10,000-round test, and had three FF-FBL and 27 FFr-II malfunctions. The three FF-FBL were bolt-carrier related. However, 26 of the 27 FFr-II were due to weak or broken hammer springs that were replaced twice, after 7461 and after 8201 rounds. The remaining FFr-II was due to a broken extractor spring. Therefore, Rifle No. 2 had 3 malfunctions due to the bolt carrier group.

Rifle No. 3 also completed the full 10,000-round test, and had 13 malfunctions: 10 FF-FBL and 3 FFr-II. The 10 FF-FBL were relative to the bolt carrier group. The 3 FFr-II all occurred when tracer ammunition was used; they occcurred late in the test and were caused in part, by a combination of heavy carbon deposits on the firing pin. In addition, the tracer rounds were more difficult to ignite than the ball rounds. The light indent problem did not occur with the ball ammunition. All 13 malfunctions of Rifle No. 3 are attributed to the bolt carrier group.

Rifle No. 4 had only one malfunction during the short time that it was in test. The test on this rifle was terminated after 1836 rounds because of a broken insert in contact with the bolt sealing ring. This broken insert left an exposed machined groove which caused the sealing rings to break. The one malfunction was due to this broken insert. Thus, no malfunctions occurred that were considered to be due to the lubrication of the bolt carrier group. This was the only rifle in which the bolt sealing ring insert broke.

Rifle No. 5 had 19 malfunctions: 6 FF-FBL and 13 FFr-LI. The test on this rifle was terminated after 9095 round because the insert in the cam path area was broken out. The 6 FF-FBL were due to the bolt carrier group, and 8 FFr-LI were due to the bolt carrier group the remaining 5 FFr-LI occurred near the end of the test and were caused by the broken insert. This rifle therefore, had 14 malfunctions that were considered to be due to the bolt carrier group.

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The five rifles had 31 malfunctions, or an average of 6 per rifle. This was a somewhat higher malfunction rate than that of the one malfunction for the composite-lubricated rifle used in the original test. However, this is still considerably lower than the 20 and 100 malfunction per rifle for the MIL-L-46000A and the unlubricated rifles respectively, used in the first test.

Although Rifles Nos. 2 and 3 completed the 10,000-round test, the composite insert in the cam path area had cracked. In Figure 9, the bolt carrier of Rifle No. 3 is shown at the end of the test with the cracked insert. Therefore, with the exception of Rifle No. 4, which was in the test for only a short time, the composite insert in the cam path area, at which the cam path wall was broken through during machining, either fell out or broke off, or was cracked. The effect of this on the test results is difficult to assess. The exact time at which these inserts cracked could not be determined; however this cracking could have occurred very early in the test. Some malfunctions undoubtedly occurred because of these cracked inserts and not because of any lubrication deficiencies. In spite of the difficulties encountered with the inserts in this one area of the carrier cam, the 6-malfunction rate per composite-lubricated rifle is considered very good.

The MIL-L-46000A-lubricated rifle (Rifle No. 6) had malfunctions: 5 FFr-LI and 2 FFr reason unknown. All these were due to the carbon buildup which caused the firing pin to stick. This sticking of the firing pin was such that the firing pin had to be pounded out at 6705 and 7904 rounds to examine the bolt to determine the reason why the rifle would not fire. The test was terminated after 7904 rounds. However, this test could have been terminated after 6705 rounds because of the heavy carbon buildup. Thus, all the composite-lubricated rifles except Rifle No. 4 lasted longer in test than the MIL-L-46000A-lubricated rifle.

If the malfunctions for both this test and the original firing test are combined, the following malfunction rates attributable to the bolt carrier group are obtained:

- (1) Composite-lubricated rifles: 0.8 per 1000 rounds
- (2) MIL-L-46000A-lubricated rifles: 2.3 per 1000 rounds
- (3) Unlubricated rifles: 12.8 per 1000 rounds

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This test shows that the self-lubricating composite does decrease the malfunction rate even though no cleaning or relubrication is carried out. The test also shows that the self-lubricating composite tends to be brittle and will crack if it is not properly placed or if it is not backed up with sufficient high-strength material.

CONCLUSIONS

The following conclusions can be drawn from the results of this firing test:



Figure 9. Bolt Carrier after 10,000 Rounds Showing Cracked Insert.

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- 1. Although the composite-lubricated rifle had some malfunctions in this test, the number was considerably less than those that occurred with the MIL-L-46000A-lubricated rifles in the first firing test. This result confirms the feasibility of using self-lubricating composite inserts in weapons.
- 2. Since the lubricating composite tends to be brittle and susceptible to cracking, care must excercised in machining the insert holes and in placing the inserts.

RECOMMENDATIONS

The use of self-lubricating composites should be considered in the design of new weapons and in the solution of difficult friction and wear problems in existing weapons.

APPENDIX-TEST DATA

This appendix contains all firing test data tables. These tables are preceded by a list that identifies the abbreviations used for the various types of malfunctions that occurred during the firing test.

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IDENTIFICATION OF MALFUNCTION TYPES GIVEN IN FIRING TEST TABLES

Malfunction		
Type	Malfunction	Description
FF-FBL	Failure to Feed	Failure of bolt to lock
FF-BOB	Failure to Feed	Bolt over base of cartridge
FF-SB	Failure to Feed	Nose of round stubbed on
		barrel extension
FFr-IJ	Failure to Fire	Light indent
FFr-U	Failure to Fire	Reason unknown
FX	Failure to Extract	
FJ	Failure to Eject	

TABLE A-1
FIRING RATES

ROUNDS		FIF		OUNDS PER MIN	TUTE)	
FIRED	Rifle No 1	'Rifle No 2	COMPOSITE -	Rifle No 4	Rifle No 5	Rifle No 6
100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300 2500 2700 2900 3100 3300 3500 3700 3900 4100 4300 4500 4700 4900 5100 5300 5500 5700 5900 6100 6300 6700 6700 7300 7300 7300 7300 73	760 765 785 700 730 735 760 775 805 806 815 820 820 820 820 820 825 825 826 825 827 785 827 770 755 775 775 775 775	770 770 740 775 730 815 820 825 820 855 860 855 845 845 845 845 820 815 820 815 820 815 820 815 820 8795 800 750 770 770 770 770 825	790 780 755 785 760 820 845 845 845 845 845 845 845 845 845 845	740 695 690 -715 685 770 765 785 (1)	780 780 785 780 775 845 850 875 885 870 875 885 886 870 875 885 886 870 875 885 870 875 885 870 875 885 870 875 885 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 870 875 877 877 877 877 877 877 877 877 877	875 850 880 850 915 860 930 950 950 950 955 945 945 945 945 945 975 910 915 925 925 925 925 925 925 925 925 925 92

TABLE A-1

FIRING RATES (continued)

ROUNDS	COMPOSITE - LUBRICATED							
FIRED	Rifle No 1	Rifle No 2			Rifle No 5	Rifle No 6		
8500 8700 8900 9100 9300 9500 9700 9900		785 7 70 790 775 775 800 765 755	805 8 2 5 820 820 825 820 810 785		835 840 815 825 (4)			

- 1. No rates after 1700 rds, gun no longer in test
- 2. No rates after 6900 rds, gun no longer in test
- 3. No rates after 7900 rds, gun no longer in test
- 4. No rates after 9100 rds, gun no longer in test

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TABLE A-2
FIRING TEST RESULTS

- (COMPOST TE-	THERT	CVILLI	DIETE	MO	7)

Malfunction Number	Malfunction	Type of	Rounds Fired	Remarks
	Туре	Fire	When Malfunct or Event Occurred	
1	FFr-LI	Automatic	881	Round fired the third time it was struck, due to ammunition.
2	FFr-LI	Automatic	1481	Round fired the second time it was struck, due to ammunition.
<u>-</u>			1900	Because of broken sealing ring in Rifle No. 4, all composite rifles were checked. Sealing ring OK; upper track inserts wearing; firing pin difficult to remove.
3	FFr-LI	Semi- Automatic	2710	Because of ammunition.
4	FF-FBL	Semi- Automatic	5901	Rifle was gymmed by hand to feed first round.
5	FFr-LI	Semi- Automatic	6701	
6	FFr-LI	Semi- Automatic	6903	Rifle taken apart. Charging handle difficult to pull back; oblong composite insert in upper right cam path area cracked in half. Rifle taken out of test.
			21	

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TABLE A-3

FIRING TEST RESULTS

(COMPOSITE-LUBRICATED RIFLE NO. 2)

Malfunction Number	Malfunction Type	Type of Fire	Rounds Fired When Malfunction or E v ent Occurred	Remarks
-			1900	Because of broken sealing rings in Rifle No. 4, all composite rifles were checked. Sealing ring OK: Firing pin difficult to remove; Bolt carrier group carbone up.
1 2 3 4 5 6	FX FX FX FX FX FX	Semi- Automatic	3190 3191 3192 3193 3194 3195	Malfunctions 1 through 6 were caused by broken extractor spring, which was replaced.
7	FF~FBL	Semi- Automatic	5901	Rifle was gymmed by hand to feed first round.
8	FFr-LI	Automatic	6801	Broken extractor- spring, replaced.
9	FF-FBL	Semi- Automatic	6901	
10	FF-FBL	Semi- Automatic	6961	
11	FFr-LI	Semi- Automatic	7376	
12 13 14 15	FFr-LI FFr-LI FFr-LI FFr-LI	Automatic	7461 7462 7463 7464	Malfunctions 12 through 15 due to broken hammer spring which was replaced.
			22	

TABLE A-3

FIRING TEST RESULTS (COMPOSITE-LUBRICATED RIFLE NO. 2) continued

16	7681 7781 7801 7821 7841 7861 7926	Malfunctions 16 through 35 occurred on tracer rounds, could be due to weak hammer spring which was replaced after 8201st round.
17 FFr-II Semi- Automatic 18	7781 7801 7821 7841 7861 7926	through 35 occurred on tracer rounds, could be due to weak hammer spring which was replaced
Automatic Automatic Automatic Automatic FFr-LI FFr-LI FFr-LI Semi- Automatic FFr-LI Semi- Automatic FFr-LI FFR-	7801 7821 7841 7861 7926	on tracer rounds, could be due to weak hammer spring which was replaced
18	7821 7841 7861 7926	could be due to weak hammer spring which was replaced
19	7821 7841 7861 7926	weak hammer spring which was replaced
20	7841 7861 7926 7966	which was replaced
21 FFr-LI Semi- 22 FFr-LI Semi- Automatic 23 FFr-LI " 24 FFr-LI " 25 FFr-LI " 26 FFr-LI Automatic 27 FFr-LI " 28 FFr-LI " 29 FFr-LI "	7861 7926 7966	
22 FFr-LI Semi- Automatic 23 FFr-LI " 24 FFr-LI " 25 FFr-LI " 26 FFr-LI Automatic 27 FFr-LI " 28 FFr-LI " 29 FFr-LI "	7966	
23		
24 FFr-LI " 25 FFr-LI " 26 FFr-LI Automatic 27 FFr-LI " 28 FFr-LI " 29 FFr-LI "		
24 FFT-LI " 25 FFT-LI Automatic 27 FFT-LI " 28 FFT-LI " 29 FFT-LI "		
26 FFT-LL Automatic 27 FFT-LL " " 28 FFT-LL " " 29 FFT-LL " "	7970	
27 FFr-II " 28 FFr-II " 29 FFr-II "	7974	
28 FFr-II " 29 FFr-II "	8001 8021	
29 FFr-II "	8041	
	8061	
30 FFr-II "	8081	
31 FFr-LI Semi-	8132	
Automatic		
32 FFr-LI "	8146	
33 FFr-LI "	8162	
34 FFr-LI "	8182	
35 FFr-LI Automatic	8201	
36 FFr-LI Semi-	8340	
Automatic		
77 POP	0256	
FF-BOB Semi-Automatic	8356	
Automatic		
	9600	Extractor spring
		replaced.
	10000	Several days after
	10000	test was completed
		oblong insert in
		upper right cam path
		area was found to be
	0.2	loose.
	23	

TABLE A-4

FIRING TEST RESULTS

(COMPOSITE-LUBRICATED RIFLE NO. 3)

Malfunction Number	Malfunction Type	Type of Fire	Rounds Fired When Malfunction of Event Occurred	Remarks
-		-	1900	Because of broken sealing ring in Rifle No. 4, all composite rifles were checked. Sealing ring OK; bolt carrier group carbon buildup; firing pin difficulto remove.
1	FF-FBL	Semi- Automatic	5901	Rifle had to be gymmed by hand to load first round
2	FF-FBL FF-FBL	Automatic Semi- Automatic	6401 6501	rifle sluggish.
4 5	FF-FBL FF-FBL	"	6921 6961	
5 6 7	FF-FBL FF-FBL	"	6963 6964	
9	FF-FBL FF-FBL	Automatic Semi- Automatic	7081 7121	
10 11	FF-FBL FFr-LI	Automatic "	7241 8001	Light indent on all tracer rounds.
12	FFr-LI	Semi- Automatic	8102	Bolt carrier taken apart, carbon
13	FFr-LI	"-	8105	buildup.
-		-	10000	Several days after test was completed, oblong insert in upper right cam pat area found split in two.
			24	

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TABLE A-6

FIRING TEST RESULTS

(COMPOSITE-LUBRICATED RIFLE NO. 5)

Malfunction Number	Malfunction Type	Type of Fire	Rounds Fired When Malfunction or Event Occurred	Remarks
-	-		1900	Because of broken sealing ring in Rifle No. 4, all composite rifles were checked. Sealing ring OK; bolt carrier group carbon buildup firing pin difficult to remove.
1	FF-FBL	Semi- Automatic	5901	Rifle had to be gymmed by hand to
2	FF-FBL	Automatic	6401	load first round.
3	FFr-LI	Ha coma or c	6881	10dd 11150 10diid.
3	FF-FBL	Semi-	6901	
	11-100	Automatic	0,01	
5	FF-FBL	Au coma cre	7121	
5	FF-FBL	Automatic	7281	
7	FF-FBL	Semi-	7361	Head halt assist
	Tr-rbL		1301	Used bolt assist.
8	DT- II	Automatic	7441	
9	FFr-II	Automatic	7461	Malfunctions 8 - 14
	FFr-LI			all on tracer rounds
10	FFr-LI	Semi-	7501	
		Automatic		
11	FFr-LI	"	7541	
12	FFr-LI	"	7581	
13	FFr-LI	Automatic	7861	
14	FFr-LI	"	8081	Bolt carrier taken
				apart; carbon
				buildup.
15	FFr-II	"	8661	
16	FFr-LI	"	8681	After firing, bolt
17	FFr-LI	Semi-	8941	remained to rear.
		Automatic		
18	FFr-II	Automatic	9094	
19	FFr-LI	11	9095	
				Rifle taken apart, oblong composite in upper right cam path
			26	area broken out.

TABLE A-7

FIRING TEST RESULTS

(MIL-L-46000-LUBRICATED RIFLE NO. 6)

Malfunction Number	Malfunction Type	Type of Fire	Rounds Fired When Malfunction or Event Occurred	Remarks
1	FFr-LI	Automatic	3501	Gun sluggish, bolt gymmed by hand 10 times, then fired OK.
2 3	FFr-U FFr-U	Automatic	6501 6502	Would not fire in automatic mode. Taken apart (except bolt assembly). No parts replaced. Finally Rired OK.
4 5	FFr-LI FFr-LI	Automatic "	670 3 6705	Carbon did not allow firing pin to 'go home'. Bolt taken appart, carbon buildup, firing pin difficult to remove; cam pin did not traverse completely.
6 7	FFr-LI FFr-LI	Automatic "	7901 7904	Rifle taken out of test after 7904 round. Bolt had carbon buildup to the extent that firing pin had to be pounded out to disassemble bolt.

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was carried out with five composite-lubricated rifles and one		
though slightly different in share, were nimend in the same		
areas as for the original test. The test on the flve composite-		
lubricated rifles had an average of six mainmentions to with one		
10 COO regards because of the fracture of the tractus. In one of		
these rifles the bolt semiling ring insert broke; this motion		
caused the sealing ring to break. In the other two composite-		
lubricated rifles removed from test, the inserts in the cam path		
area fractured and fell out because, when the insert hole was		
machined, it broke through the cam path wall. The impact of the		
cam pin against the exposed portion of the insert eventually		
caused cracking. Nevertheless, these tests have demonstrated the		
feasibility of the use of the self-lubricating inserts. However,		
care must be exercised to insure that the inserts fit properly		
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